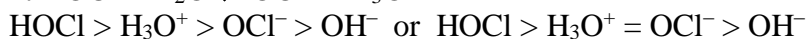
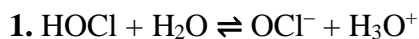


ANSWERS: Relative concentrations of dissolved species



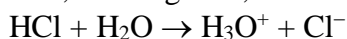
HOCl partially dissociates, and so the equilibrium lies to the LHS/favours the reactants; therefore HOCl is present in the greatest amounts.

H_3O^+ and OCl^- are produced in equal amounts / there is a small contribution to H_3O^+ from water therefore $\text{H}_3\text{O}^+ > \text{OCl}^-$

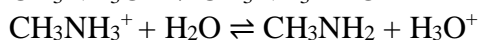
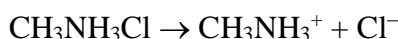
Because there is a relatively high $[\text{H}_3\text{O}^+]$, the $[\text{OH}^-]$ is very low (or links to K_w).



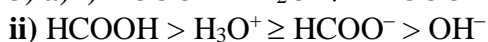
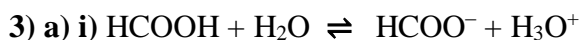
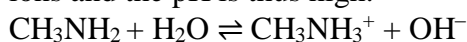
HCl, a strong acid, reacts completely with water to form 1 mol L^{-1} H_3O^+ and hence a low pH.



$\text{CH}_3\text{NH}_3\text{Cl}$ dissociates completely in water to form CH_3NH_3^+ and Cl^- . CH_3NH_3^+ , a weak acid, partially reacts with water to form less than 1 mol L^{-1} H_3O^+ and hence a higher pH than HCl.



CH_3NH_2 , a weak base, partially reacts with water to form OH^- ions. So there are more OH^- ions than H_3O^+ ions and the pH is thus high.



Methanoic acid is a weak acid so the equilibrium favours HCOOH. Dissociation produces similar amounts of H_3O^+ and HCOO^- . Dissociation of HCOO^- produces a small amount of OH^- / water dissociates to form a small amount of H_3O^+ and OH^- in equal amounts and after the dissociation of HCOOH there will be slightly more H_3O^+ than HCOO^- .

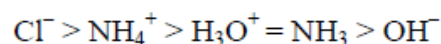
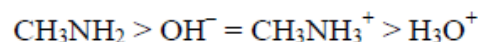
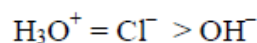
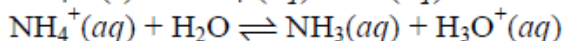
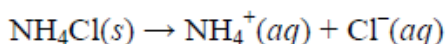
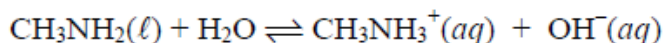
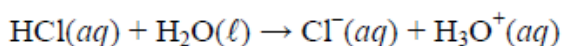
b) HCl is a strong acid and completely dissociates into its ions. It has a low pH due to a high $[\text{H}_3\text{O}^+]$.

NH_4Cl is an acidic salt that completely dissociates into its ions producing NH_4^+ . NH_4^+ is a weak acid so partially dissociates into H_3O^+ , however, although acidic its pH is not as low as HCl. The concentration of $[\text{H}_3\text{O}^+]$ is lower.

NH_3 is a weak base, its reaction with water produces only a limited amount of OH^- compared to NaOH which is a strong base and fully dissociates to produce the highest concentration of OH^- and hence the highest pH.

Conductivity relates to the number of ions in solution.

4.



Note: Do not accept H^+ , states are not required, equation may be in part (c).

(allow inclusion of H_2O and commas in place of $>$)

HCl is a strong acid, so fully reacts with water to produce a high $[\text{H}_3\text{O}^+]$. $\text{pH} < 7$.

NH_4Cl is an acidic salt that completely dissociates into its ions producing NH_4^+ and Cl^- . NH_4^+ is a weak acid, so only partially reacts with water to produce H_3O^+ . $\text{pH} < 7$, but higher than HCl since NH_4^+ has a lower $[\text{H}_3\text{O}^+]$ than HCl.

CH_3NH_2 is a weak base, so only partially reacts with water to produce OH^- ions. $\text{pH} > 7$.

Electrical conductivity relates to the concentration of mobile charged particles present. In the case of solutions, conductivity relates to the number of ions present.

Both HCl and NH₄Cl completely react with water to produce a high concentration of ions, so their conductivity will be high (and equal).

Since CH₃NH₂ is a weak base, it partially reacts with water to produce only a few ions in the solution, making it a poor electrical conductor.

5. a) NH₃ weak base

NaCl neutral

NH₄Cl weak acid

HF weak acid

b)

$\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$ <p>Equilibrium is to the left, so the greatest concentration of a species is NH₃. For each NH₃ that reacts equal amounts of NH₄⁺ and OH⁻ are formed and are greater than the OH⁻ and H₃O⁺ formed by the dissociation of water.</p> $\text{NH}_3 > \text{OH}^- \geq \text{NH}_4^+ > \text{H}_3\text{O}^+$	$\text{HF} + \text{H}_2\text{O} \rightleftharpoons \text{F}^- + \text{H}_3\text{O}^+$ <p>Equilibrium is to the left, so the greatest concentration of a species is HF. For each HF that reacts equal amounts of F⁻ and H₃O⁺ are formed and are greater than the OH⁻ and H₃O⁺ formed by the dissociation of water.</p> $\text{HF} > \text{H}_3\text{O}^+ \geq \text{F}^- > \text{OH}^-$
--	--

6. a) $\text{NH}_4\text{Cl}(s) \rightarrow \text{NH}_4^+(aq) + \text{Cl}^-(aq)$

$\text{NH}_4^+ + \text{H}_2\text{O} \rightarrow \text{NH}_3 + \text{H}_3\text{O}^+$

b) **A** = Cl⁻ **B** = NH₄⁺ **C** / **D** = H₃O⁺ / NH₃ **E** = OH⁻

- NH₄⁺ and Cl⁻ form in equal amounts from dissociation of salt in water.
 - Some NH₄⁺ reacts further with water so [NH₄⁺] < [Cl⁻].
 - H₃O⁺ and NH₃ formed in equal amounts from the reaction of NH₄⁺ with water.
 - [NH₃] « [NH₄⁺], since only small amount of NH₄⁺ reacts (NH₄⁺ is a weak acid / small dissociation constant).
 - [OH⁻] « [H₃O⁺] since solution is acidic.
 - [H₃O⁺] × [OH⁻] = 1 × 10⁻¹⁴.
- [H₃O⁺] = [NH₃] from NH₄⁺ dissociating.

7. $\text{NaOH} \rightarrow \text{Na}^+ + \text{OH}^-$

$\text{CH}_3\text{NH}_2 + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{NH}_3^+ + \text{OH}^-$

$\text{CH}_3\text{NH}_3\text{Cl} \rightarrow \text{CH}_3\text{NH}_3^+ + \text{Cl}^-$

$\text{CH}_3\text{NH}_3^+ + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{NH}_2 + \text{H}_3\text{O}^+$

NaOH is a strong base and completely dissociates into its ions. Strong base, so produces more OH⁻ ions in solution than CH₃NH₂. pH > 7 and greater than for CH₃NH₂.

CH₃NH₂ is a weak base, so only some ions react with water to produce OH⁻ ions. pH > 7.

CH₃NH₃Cl is an acidic salt that completely dissociates into its ions producing CH₃NH₃⁺.

CH₃NH₃⁺ is a weak acid, so partially dissociates in water to produce H₃O⁺ ions. So pH < 7.

Conductivity relates to the number of ions in a solution.

NaOH and CH₃NH₃Cl completely dissociate, so produce a large number of ions, so high conductivity.

CH₃NH₂ has an equilibrium reaction with water, so only a few ions are produced, so low conductivity.

8. $\text{HOBr}(aq) + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+(aq) + \text{OBr}^-(aq)$

9. a) i) $\text{CH}_3\text{NH}_2 + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{NH}_3^+ + \text{OH}^-$

(NH₄Cl → NH₄⁺ + Cl⁻)

$\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{NH}_3 + \text{H}_3\text{O}^+$

ii) CH₃NH₂ > OH⁻ > (or =) CH₃NH₃⁺ > H₃O⁺

Cl⁻ > NH₄⁺ > H₃O⁺ > (or =) NH₃ > OH⁻

b) CH_3NH_2 is a weak base and only reacts slightly with water / it is a weak base, equilibrium lies to the left/only partial dissociation.

As most aminomethane remains in the molecular state there are few ions in the solution, making it a weak electrolyte.

10) i) C

Strong acid – no acid molecules, HA , are present so acid must have completely dissociated in solution.

Dilute – only a small number of solute particles compared to number present in B.

ii) A

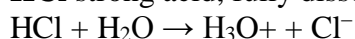
Weak acid – particles in solution are mostly acid molecules with only a few conjugate base and hydronium ions present implying only partial dissociation. Concentrated – a large number of solute particles present in the given volume of water.

iii) D

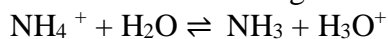
Both the acid HA particles and its conjugate base A^- particle are present in similar quantities.

11. HCl , NH_4Cl , NaCl , NH_3 , NaOH

HCl strong acid, fully dissociates giving high concentration of H_3O^+ .

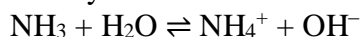


NH_4Cl dissolves to give a solution of NH_4^+ and Cl^- ions. The NH_4^+ ions are weakly acidic and partially dissociate in water to give a small increase in $[\text{H}_3\text{O}^+]$.



NaCl dissolves to give Na^+ and Cl^- ions, but neither of these have any reaction with water so solution is neutral.

NH_3 is a weak base and reacts with water to give a small increase in the conc of OH^- , making the solution weakly alkaline.



NaOH is a strong base and fully dissociates, giving a high concentration of OH^- ions.

